PATENT
2880 (203-3440)

CIRCUIT FOR CONTROLLING ARC ENERGY FROM AN ELECTROSURGICAL GENERATOR

CROSS REFERENCE TO RELATED APPLICATIONS:

This application claims the benefit of priority to U.S. Provisional Application Serial No. 60/432,384 filed on December 10, 2002, the entire contents of which are hereby incorporated by reference herein.

BACKGROUND

1. Technical Field

The present disclosure is directed to electrosurgery and, in particular, to circuitry for controlling arc energy from an electrosurgical generator for ablating, cauterizing, coagulating, cutting and/or sealing body tissue during electrosurgery.

2. Description of the Related Art

Electrosurgical generators do not have the ability to vary the amount of energy contained within an arc to control the amount of tissue vaporized and the amount of current applied to tissue to limit collateral damage to surrounding tissue, e.g., thermal spread. The ultimate amount of arc energy from the electrosurgical generator to the tissue is dependent on patient resistance, power setting and the internal impedance of the electrosurgical generator.

Vaporization of tissue is proportional to the amount of energy in an arc. This energy in combination with the Cathode Fall Voltage, derives the power for vaporization. Thermal spread is dependent on the amount generated within the tissue is dependent on tissue resistive and the arc energy squared. As can be appreciated, by not controlling the thermal spread the depth of ablation is difficult to predict and control. Electrosurgery is thus disadvantageous in applications in which only a fine layer of tissue is to be ablated, or in areas of the body such as the heart or near the spinal cord where resistive heating can result in undesirable collateral damage to critical tissue and/or organs.

U.S. Patent No. 6,413,256 B1 to Truckai et al. discloses an electrosurgical system where a spark gap is utilized in series with the electrosurgical generator output current to control resistive heating of tissue during electrosurgery. The spark gap limits the arc energy, but is prone to introducing high frequency oscillations that can have an undesirable effect on the tissue, as well as increase the high frequency leakage currents.

Therefore, it is an aspect of the present disclosure to provide a circuit for controlling arc energy from the electrosurgical generator to minimize the amount of tissue vaporized and to also minimize the amount of current applied to tissue to limit thermal spread without introducing high frequency oscillations or other undesirable effects.

SUMMARY

A circuit is disclosed which minimizes the amount of tissue vaporized during a first half (positive half cycle) of an electrosurgical current cycle and minimizes the amount of current applied to tissue during a second half (negative half cycle) of the electrosurgical current cycle to limit thermal spread. The circuit is preferably provided within an electrosurgical generator to provide an electrosurgical generator which is capable of controlling the amount of energy delivered to a patient during electrosurgery on a per arc basis.

In a first embodiment, the circuit includes a diode-resistor block having a pair of diodes in series with an output current of the electrosurgical generator. In a second embodiment, the diode-resistor block includes the pair of diodes in parallel with the output current of the electrosurgical generator. In both embodiments, each diode is biased opposite from the other diode, thus splitting the output current into two paths. The diode-resistor block in both embodiments includes two resistors which are provided in each of the two paths. These resistors, depending on their resistive value, limit the current for each half cycle.

As long as the current for either half cycle remains above a predetermined minimum current, I_{min}, an arc is formed. The energy in the arc is limited by the resistors. Accordingly, the arc energy for vaporizing tissue during the positive half cycle and the arc energy for causing thermal spread during the negative half cycle are controlled.

In alternate embodiments, the resistors of the diode-resistor block are replaced with potentiometers for allowing a user of the electrosurgical generator to "dial" in preferred levels of tissue vaporization and thermal spread. With these embodiments, the surgeon is given an almost unlimited ability to vary the ratio between the amount of tissue vaporized and thermal spread.

Further features of the above embodiments will become more readily apparent to those skilled in the art from the following detailed description of the apparatus taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments will be described herein below with reference to the drawings wherein:

FIG. 1 is a schematic diagram of a circuit according to a first embodiment;

FIG. 2 is a schematic diagram of a circuit according to a second embodiment;

FIG. 3 is a schematic diagram of a circuit according to a third embodiment; and

FIG. 4 is a schematic diagram of a circuit according to a fourth embodiment.

DETAILED DESCRIPTION

Reference is made to the drawings where like reference numerals refer to similar elements. Referring to FIG. 1, there is shown a schematic diagram of a circuit according to one embodiment of the present disclosure generally identified by reference numeral 100. Circuit 100 includes a diode-resistor block 102 in series with an output current 104 of an electrosurgical generator 106. The diode-resistor block 102 includes a pair of diodes 108a, 108b biased opposite from each other, thus splitting the output current 104 into two paths 110a, 110b. Preferably, the diodes 108a and 108b are high voltage, fast recovering diodes.

The diode-resistor block 102 further includes resistors 112a, 112b in each of these two paths 110a, 110b. These resistors 112a, 112b, depending on their resistive value (including having no resistive value, i.e., short), limit the current for each half cycle of the output current 104. Preferably, the resistance value for resistors 112a and 112b is in the range of about 50 ohms to about 2000 ohms.

The output current 104 is further limited by the patient resistance 114 in series with the diode-resistor block 102. The resistive value of the resistor 114 is typically in the range of 100 to 4000 ohms. By limiting the current for the positive half cycle, the circuit 100 controls the amount of vaporization of the tissue. By limiting the current for the negative half cycle, the circuit 100 controls thermal spread to surrounding tissue. During the periods of reduced power, the thermal energy is allowed to dissipate which reduces the overall thermal conduction and reduces the amount of steam exiting the surgical site. A detailed explanation of this effect is

disclosed in commonly-assigned U.S. Patent No. 6,228,080, the entire contents of which are hereby incorporated by reference herein.

In circuit 100, the voltage can drop at two spots: across resistor 112a and across patient 114 for maintaining arc at a predetermined minimum voltage, V_{min}, the minimum voltage point at which the arc disappears). As can be appreciated, as long as the current for either half cycle remains above a predetermined minimum current, I_{min}, an arc is formed. The energy in the arc is limited by the resistors 112a and 112b and patient resistance 114. Accordingly, the arc energy for vaporizing tissue during the positive half cycle and the arc energy for causing thermal spread during the negative half cycle are controlled.

It is provided that according to the resistive values selected for the resistors 112a and 112b the output current 104 may be limited for only one of the half cycles.

In an alternate embodiment according to the present disclosure as shown by FIG. 3, a circuit 300 is provided which is similar to circuit 100. However, in this embodiment, the resistors 112a, 112b are replaced with potentiometers 312a, 312b for allowing a surgeon to select the resistive value (including no resistive value, i.e., short) for potentiometers 312a, 312b using dials 320a, 320b, respectively, on the electrosurgical generator 106 for varying the ratio between the amount of tissue vaporized during the positive half cycle and thermal spread during the negative half cycle. In circuit 300, the voltage can drop at two spots: across potentiometer 312a

and across the patient 114 for maintaining arc at a predetermined minimum voltage, V_{min}.

It is envisioned that by selecting the resistive values for the potentiometers 312a and 312b, the output current 104 may be limited for only one of the half cycles.

Referring to FIG. 2, there is shown a schematic diagram of a circuit 200 according to another embodiment of the present disclosure. Circuit 200 includes a diode-resistor block 202 in parallel with the output current 204 of an electrosurgical generator 206. The diode-resistor block 202 includes a pair of diodes 208a, 208b biased opposite from each other, thus splitting the output current 204 into two paths 210a, 210b. The diode-resistor block 202 shunts the current around the patient 214. This forms two paths; the path through the diode circuit block 202 and the path through the patient 214.

The diode-resistor block 202 further includes resistors 212a, 212b in each of these two paths 210a, 210b, respectively. These resistors 212a, 212b, depending on their resistive value (including having no resistive value, i.e., short), shunt the current for each half cycle of the output current 204.

The output current 204 is further limited by the patient resistance 214 in parallel with the diode-resistor block 202. The resistive value of the patient 214 is typically in the range of 100 to 4000 ohms. By shunting the current for the positive half cycle, the circuit 200 controls the amount of vaporization of the tissue. By

shunting the current for the negative half cycle, the circuit 200 controls thermal spread to surrounding tissue. In circuit 200, the predetermined minimum voltage, V_{min}, is controlled within the generator 106 and, thus, the voltage does not drop across the patient 214 to maintain or control V_{min}.

In short, as long as the current for either half cycle remains above a predetermined minimum current, I_{min}, an arc is formed. The energy in the arc is shunted by the resistors 212a and 212b. Accordingly, the arc energy for vaporizing tissue during the positive half cycle and the arc energy for causing thermal spread during the negative half cycle are adequately controlled. Moreover and depending upon the resistive values selected for the resistors 212a and 212b the output current 204 may be limited for only one of the half cycles.

In an alternate embodiment, as shown by FIG. 4, a circuit 400 is provided which is similar to circuit 200. However, in this embodiment, the resistors 212a, 212b are replaced with potentiometers 412a, 412b for allowing a surgeon to select the resistive value (including no resistive value, i.e., short) for potentiometers 412a, 412b using dials 420a, 420b, respectively, on the electrosurgical generator 106 for varying the ratio between the amount of tissue vaporized during the positive half cycle and thermal spread during the negative half cycle. Much like circuit 200 described above, in 400 the predetermined minimum voltage, V_{min}, is controlled within the generator 106 and thus, the voltage does not drop across the patient 214 to maintain or control V_{min}. The output current 104 may be shunted for only one of the half cycles by selecting the values for the potentiometers 412a and 412b.

Accordingly, the present disclosure provides an electrosurgical generator which is capable of controlling the amount of energy delivered to a patient during electrosurgery on a per arc basis. As can be appreciated, controlling the power reduces the overall effect on the tissue and the surrounding tissue.

Although the present disclosure has been described with respect to preferred embodiments, it will be readily apparent to those having ordinary skill in the art to which it appertains that changes and modifications may be made thereto without departing from the spirit or scope of the disclosure.